INTERSTELLAR OXYGEN-17

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ABSTRACT

Emission from the $J = 1 \rightarrow 0$ transition of $^{12}C^{17}O$ has been detected in the two molecular clouds associated with the Orion Nebula and the ρ Ophiuchi complex. $^{17}O/^{18}O$ ratios near the terrestrial value are found in both sources.

Subject headings: molecules, interstellar — abundances

I. INTRODUCTION

We have observed line emission from the molecular clouds associated with the Orion Nebula and the ρ Ophiuchi complex which we attribute to the $J = 1 \rightarrow 0$ rotational transition of $^{12}C^{17}O$ at 112,359.27 MHz. This marks the first detection of ^{17}O outside the solar system. The Orion molecular cloud, the most intense known source of $^{12}C^{16}O$ line emission, has been the subject of a number of isotope studies (Wilson *et al.* 1972; Penzias *et al.* 1973); the ρ Oph complex contains the most intense known source of $^{13}C^{16}O$ line emission. This latter source was recently discovered during an extended mapping of the region (Encrenaz 1973).

II. OBSERVATIONS

Observations were made with the 36-foot (11-m) antenna of the National Radio Astronomy Observatory on Kitt Peak.[1] In addition, a $^{12}C^{18}O$ comparison spectrum taken with the 16-foot (5-m) University of Texas antenna[2] is used in our analysis. The BTL RG-138 receiver used in this work had a double-sideband noise temperature of 800° K. Frequency switching of the local oscillator was used, and calibrations were made by synchronously placing an absorbing disk over the feed horn (Penzias and Burrus 1973).

Plots of the observed $^{12}C^{17}O$ antenna temperature profiles are shown in figures 1 and 2. Corresponding $^{12}C^{18}O$ spectra are plotted in the same figures. The Orion $^{12}C^{18}O$ spectrum was taken with the Kitt Peak antenna and the same receiver as the $^{12}C^{17}O$ data while the ρ Oph $^{12}C^{18}O$ spectrum was taken with the smaller University

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[2] The millimeter-wave observatory is operated by the Electrical Engineering Research Laboratory of the University of Texas at Austin with support from NASA, NSF, and the McDonald Observatory.
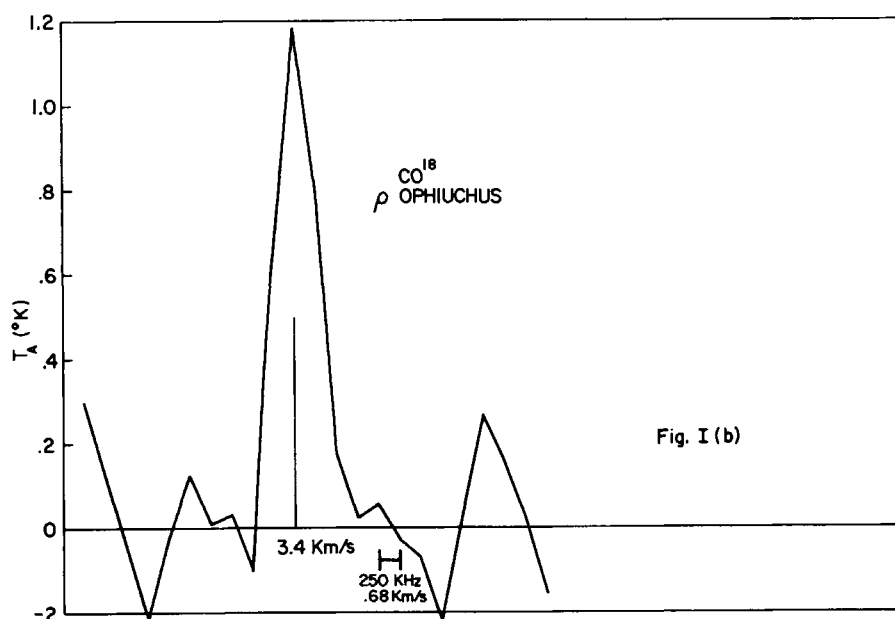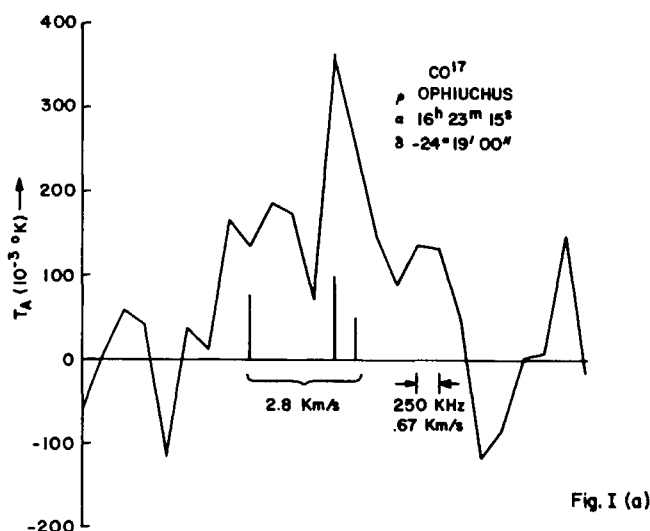
Fig. 1.—(a) $^{12}C^{17}O$ and (b) $^{12}C^{18}O$ spectra in the ρ Oph complex. Antenna temperature is plotted versus frequency. The velocity scale is indicated, and the line frequencies are plotted at the best fit velocities. The 0.6 km s^{-1} difference between the $^{12}C^{18}O$ and $^{12}C^{17}O$ is about one channel and is not significant. The $^{12}C^{18}O$ data have been scaled in amplitude as explained in the text.

of Texas antenna. Since the ρ Oph source has been found to be extended, the difference in beam sizes (2.'4 at Texas versus 1.'1 at Kitt Peak) plays no significant role in the comparison. However, we have had to take into account the greater beam efficiency of the Texas antenna by scaling its spectrum by a factor of 0.7. This scale difference has been well established in our CO studies.

Unlike the more abundant CO isotopic species, $^{12}C^{17}O$ has appreciable hyperfine structure caused by the electric quadrupole interaction of the spin 5/2 of ^{17}O. Rosenblum and Nethercot (1957) report that the hyperfine structure of the $J = 1$ to $J = 0$ transition of the molecule consists of a triplet whose spacings are 260 and 1300 kHz. Figure 1 clearly demonstrates the presence of $^{12}C^{17}O$ in both sources, but our signal-
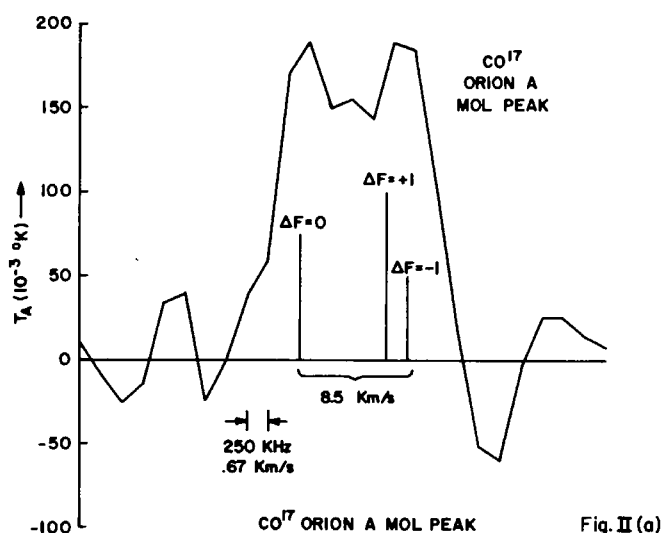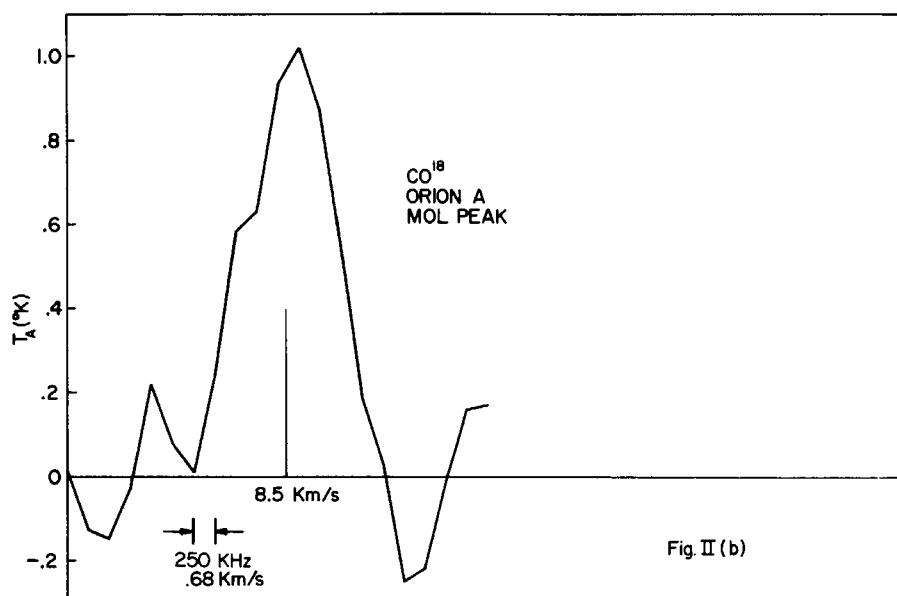
Fig. 2.—(a) $^{12}C^{17}O$ and (b) $^{12}C^{18}O$ spectra at the Orion molecular cloud peak. Antenna temperature is plotted versus frequency. The velocity scale is indicated, and the line frequencies are plotted at the best-fit velocities.

to-noise ratio is not good enough to accurately compare the relative intensities of the components.

III. DISCUSSION

The relative abundance of ^{17}O is an important astrophysical quantity because of possible enrichment during the hot CNO cycle (Arnett 1973). If, as would seem likely, the $^{12}C^{18}O/^{12}C^{17}O$ line intensity ratio reflects the relative abundance of ^{18}O and ^{17}O, our data yield a result of 3.6 ± 1.0 in Orion A and 4.0 ± 2.0 in ρ Oph. For comparison, the terrestrial value of this quantity is 5.5 (Cameron 1959). We have no a priori reason to expect this ratio to be terrestrial, although a number of previous relative isotope abundance determinations have been found to be rather close to the

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terrestrial values (Wilson *et al.* 1972; Penzias *et al.* 1972), and our work indicates that oxygen-17 may well be added to that list.

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